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PHYSICS 20

STUDENT MATERIALS





PHYSICS 20

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This package of Student Materials contains

- End-of-Course Exam
- Performance Assessment
- Data Sheet and Spreadsheet

A

CLASSROOM
ASSESSMENT
MATERIALS

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This package of Student Materials contains

- ***End-of-Course Exam***
- ***Performance Assessment***
- ***Data Sheet and Scoring Criteria***

In addition to the Student Materials, this classroom assessment package includes

- ***Teacher Manual***
- ***Examples of Students' Responses***

to the student's knowledge of the subject matter and to the student's ability to apply the knowledge to the student's own work.

The student's knowledge of the subject matter and the student's ability to apply the knowledge to the student's own work are the two main factors in the student's learning.

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This package of Student Materials contains

- End of Course Exam
- Performance Assessment
- Unit 2 and Unit 3

In addition to the Student Materials, the following resources are available to the student:

- Teacher Manual
- Examples of Student Responses

The following resources are available to the student:

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Physics 20

End-of-Course Exam

End of Course Exam

End-of-Course Exam

Description

Time: 2.0 h. You may take an additional 0.5 h to complete the exam.

Total possible marks: 61

This is a **closed-book** exam consisting of

- 31 selected-response and 9 numerical-response questions, each with a value of one mark
- 2 written-response questions, with a combined value of 21 marks

This exam contains sets of related questions. A set of questions may contain selected-response and/or numerical-response questions.

A data sheet is included.

Instructions

Fill in the information required on the answer sheet and the exam booklet as directed by your teacher.

You are expected to provide your own scientific calculator.

If you wish to change an answer, erase **all** traces of your first answer.

Consider all numbers used in the exam to be the result of a measurement or observation.

Read each question carefully.

Selected Response

Decide which of the choices **best** completes the statement or answers the question.

Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This exam is for the subject of

- A. biology
- B. physics
- C. chemistry
- D. science

Answer Sheet

(A) ☒ (C) (D)

Numerical Response

Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.

If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.

Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.

Examples

Calculation Question and Solution

If a 121 N force is applied to a 77.7 kg mass at rest on a frictionless surface, the acceleration of the mass would be _____ m/s².
(Round and record your answer to three digits on the answer sheet.)

$$a = \frac{F}{m}$$

$$a = \frac{121 \text{ N}}{77.7 \text{ kg}} = 1.5572716 \text{ m/s}^2$$

**Record 1.56 on the
answer sheet —**

1	.	5	6
	●	●	
0	0	0	0
●	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	●	5
6	6	6	●
7	7	7	7
8	8	8	8
9	9	9	9

Calculation Question and Solution

A microwave of wavelength 16 cm has a frequency of $b \times 10^9$ Hz. The value of b is _____.
(Round and record your answer to two digits on the answer sheet.)

$$\begin{aligned}f &= c/\lambda \\&= (3.00 \times 10^8 \text{ m/s})/(0.16 \text{ m}) \\f &= 1.875 \times 10^9 \text{ Hz}\end{aligned}$$

Record 1.9 on the
answer sheet →

1	.	9	
---	---	---	--

●	•		
0	0	0	0
●	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	●	9

Written Response

Write your answers in the exam booklet as neatly as possible.

For full marks, your answers must be well organized and address **all** the main points of the question.

Relevant scientific, technological, and/or societal concepts and examples must be identified and explicit.

Descriptions and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formula.

Your answers **should be** presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.

Do not start the exam until told to do so by your teacher.

Use the following information to answer the next question.

A student was given the following situations:

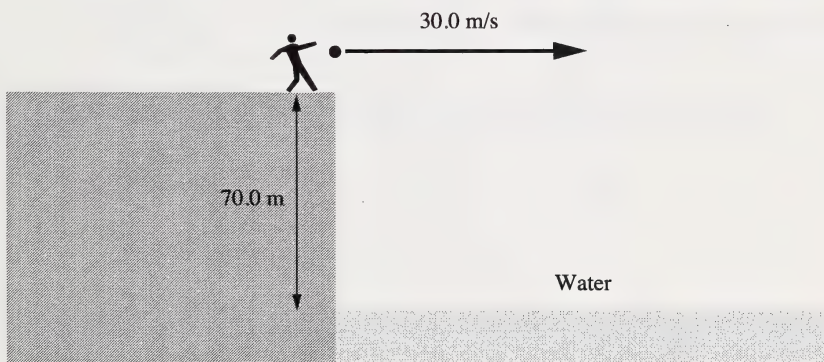
- 1 A cold air mass has a temperature of 5°C .
- 2 A car increases its velocity to $+90\text{ km/h}$.
- 3 An airplane changes its position to $\text{N } 52^{\circ}\text{ W}$.
- 4 A track contestant runs the 100 m dash in 9.89 s.
- 5 A submarine covers a displacement of 150 km, north.

1. Which situations are examples of scalar quantities?

- A. 1 and 3 only
- B. 1 and 4 only
- C. 2, 3, and 5 only
- D. 2, 4, and 5 only

Use the following information to answer the next two questions.

A boy stands on the edge of a sea cliff 70.0 m high and throws a rock horizontally, at a velocity of 30.0 m/s.



Numerical Response

1. The time required for the rock to contact the water is _____ s.
(Round and record your answer to three digits.)

2. How far from the base of the cliff will the rock contact the water?

- A. 113 m
- B. 132 m
- C. 150 m
- D. 183 m

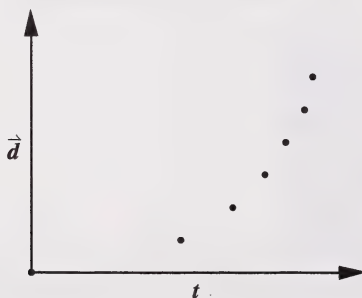
Use the following information to answer the next question.

Descriptions of Motion

- 1 An object is released from the top of a building and timed as it falls past each uniformly spaced floor.
- 2 A sports car starts from a stop sign and uniformly increases its speed to 100 km/h in 10 seconds.
- 3 A ball is rolled down a board inclined at 30° , and the time of travel is recorded for uniformly marked distances.
- 4 A tractor travels with uniform motion, and the time of travel is recorded for uniformly marked distances.

Numerical Response

This is a position–time graph related to moving objects:

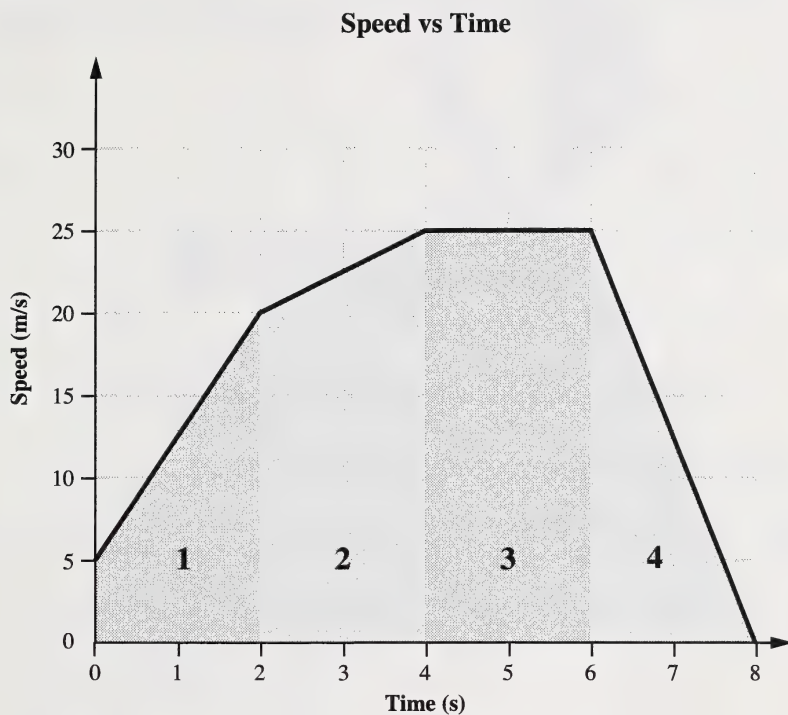


2. The statements that could be correctly represented by the position–time graph are, in any order, _____.

(Record your answer as .)

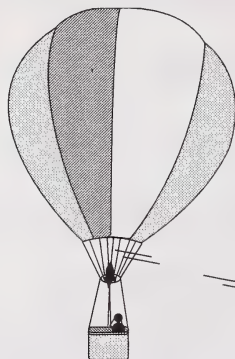
Use the following graph to answer the next two questions.

The following graph describes the motion of a truck over an 8 second time interval.



3. Which section of the graph indicates that a net force of zero was acting on the truck?
- A. 1
 - B. 2
 - C. 3
 - D. 4
4. Which section of the graph indicates the largest positive force acting on the truck?
- A. 1
 - B. 2
 - C. 3
 - D. 4

5. A balloon is rising vertically at a velocity of 4.0 m/s while a west wind is blowing at 10 m/s .



Balloon rising at 4.0 m/s



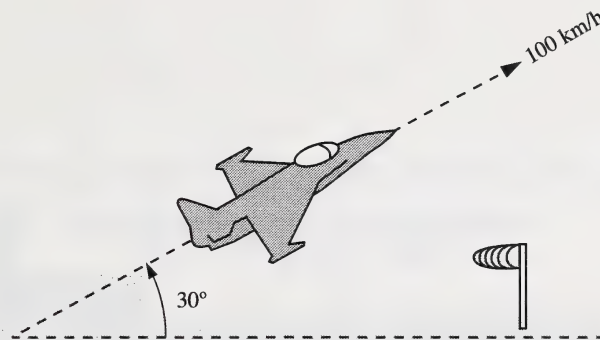
West wind of 10 m/s

Relative to the ground, the angle of ascent of the balloon is

- A. 21°
- B. 22°
- C. 69°
- D. 68°

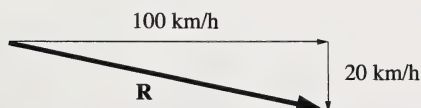
Use the following information to answer the next three questions.

An air force pilot takes off from a runway, heading due east at 100 km/h. The plane climbs at an angle of 30° from the ground. When it reaches altitude, it encounters a 20 km/h crosswind from the north.



6. During the takeoff, the vertical and horizontal components of the plane's velocity, respectively, are
- A. 87 km/h, 50 km/h
 - B. 50 km/h, 87 km/h
 - C. 50 km/h, 50 km/h
 - D. 100 km/h, 100 km/h
7. The correct vector diagram, as viewed from above, to find the plane's velocity when it reaches altitude would be

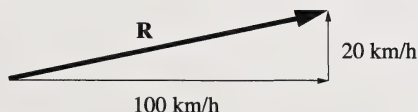
A.



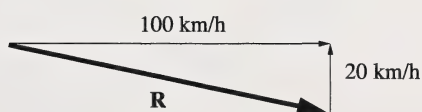
B.



C.



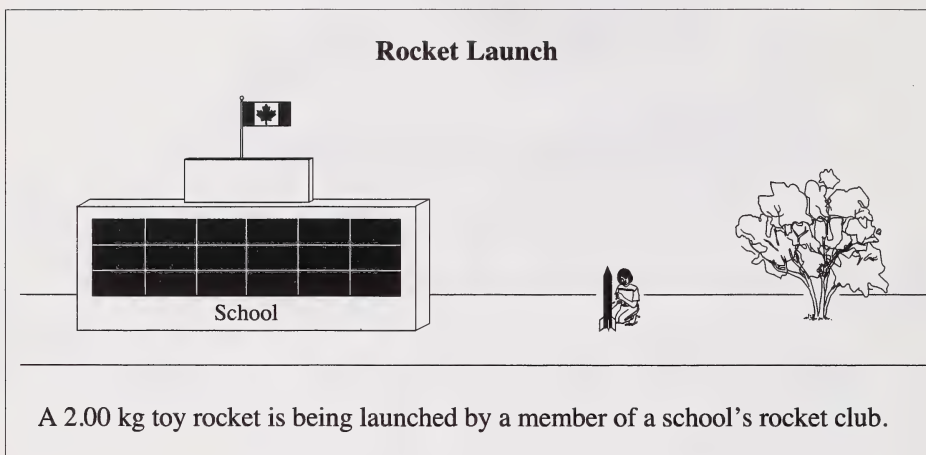
D.



8. The pilot is aware of the crosswind and aims his craft so that it will fly due east. In what direction does he point the nose of the plane?

A. 11° N of E
B. 112° N of E
C. 79° N of E
D. 0° due east

Use the following information to answer the next two questions.



9. The weight of the rocket is

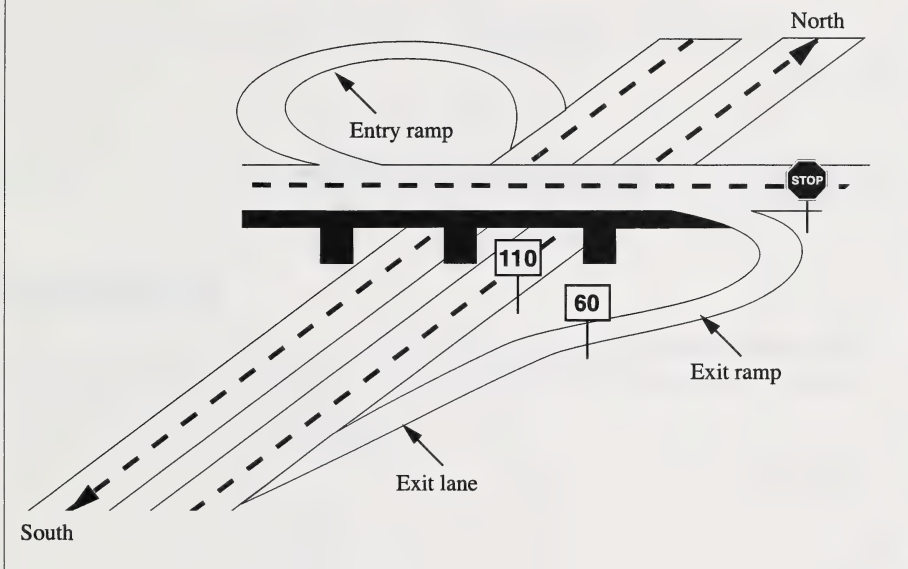
A. 2.00 N
B. 2.00 kg
C. 19.6 N
D. 19.6 kg

10. What is the initial exhaust force required to overcome gravity and then accelerate the rocket vertically at 5.80 m/s^2 ?

A. 8.02 N
B. 11.6 N
C. 19.6 N
D. 31.2 N

Use the following information to answer the next question.

The design for an overpass on Highway 2 is shown. The roadway of the overpass is 6.5 m above the highway surface. The speed limit on the exit or entry ramp is 60 km/h (16.7 m/s) and on the highway is 110 km/h (30.6 m/s).



Numerical Response

3. On the 120 m-long ramp, the average force applied by the engine of a car is 3.0×10^3 N. If the engine power is rated at 71.0 kW, then the car accelerated for _____ seconds.
(Round and record your answer to two digits.)

Use the following information to answer the next two questions.

The speed of sound in a gas is given by the equation

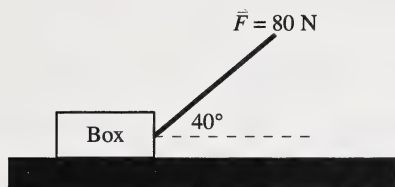
$$v = \sqrt{\frac{kP}{\rho}},$$

where v is the speed (m/s), k is a constant, P is the pressure (N/m²), and ρ is the density (kg/m³).

11. If the speed is 300 m/s, the pressure is 250 N/m², and the density is 1.05×10^{-6} kg/m³, the numeric value of k is
- A. 3.78×10^{-4}
 - B. 1.39×10^{-3}
 - C. 1.93×10^{-6}
 - D. 3.73×10^{-2}
12. The SI unit for k is
- A. s/m
 - B. m/s
 - C. s²/m²
 - D. no units

Use the following information to answer the next question.

A force of 80 N is applied to a box by pulling on a rope at an angle of 40° to the horizontal as shown.



Numerical Response

4. The applied force can be broken into vertical and horizontal components. The vertical component of the force is ab N. The horizontal component of the force is cd N. The values of ab and cd are _____.
(Record your answer as .)

13. A pop can is dropped in a car that is travelling at 90 km/h. The horizontal velocity of the can, with respect to the roadway, is
- A. 0.0 km/h
 - B. 90 km/h forwards
 - C. 90 km/h backwards
 - D. 90 km/h downwards

Use the following information to answer the next two questions.

Road Safety

The speed limits on Alberta highways are 110 km/h (30.6 m/s) during the day, 100 km/h (27.8 m/s) at night, and 90 km/h (25 m/s) in the national parks.

14. The centripetal forces on a car's tires will
- A. increase with the size of the tire
 - B. be greatest in the parks
 - C. be greatest during the night
 - D. be greatest during the day
15. A car's engine heats up as it inefficiently converts chemical potential energy to mechanical kinetic energy. Car tires also heat up. This is because the tires are converting
- A. mechanical kinetic energy to heat
 - B. heat to mechanical kinetic energy
 - C. chemical potential energy to heat
 - D. gravitational potential energy to mechanical kinetic energy

Use the following information to answer the next question.

A student summarized some sixteenth- and seventeenth-century ideas about planetary motion.

- 1 The paths of the planets are ellipses, with the centre of the Sun at one focus.
- 2 The force between the Sun and a planet varies inversely with the square of its distance from the Sun.
- 3 An imaginary line from the Sun to a planet sweeps out equal areas in equal time intervals.
- 4 The ratio of the squares of the periods of any two planets revolving around the Sun is equal to the ratio of the cubes of their average distance from the Sun.

16. Which ideas form the basis of Kepler's laws regarding planetary motion?

- A. 1 and 2 only
 - B. 2 and 4 only
 - C. 1, 3, and 4 only
 - D. 1, 2, 3, and 4
-

Numerical Response

5. A satellite is moving around Earth in a geosynchronous orbit. This means it is directly above one spot on Earth at all times. The period of this orbit in scientific notation is $b \times 10^w$ h. The value of b is _____.

(Round and record your answer to two digits.)

Use the following information to answer the next question.

The length of a skid mark in a collision can be used to determine if a motorist has been speeding. The relationship between vehicle speed and skid mark length is given by

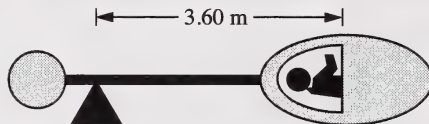
$$S = \frac{v^2}{2g\mu},$$

where v = vehicle speed (m/s)
 g = acceleration due to gravity
 μ = coefficient of friction (0.30 for asphalt)

17. The posted speed limit on a residential asphalt street is 50.0 km/h (13.9 m/s). After an accident, the skid mark is found to be 60.0 m long. How much **longer** is this skid mark than it would have been **if** the vehicle had been travelling at the posted speed limit?
- A. 27 m
B. 28 m
C. 29 m
D. 33 m

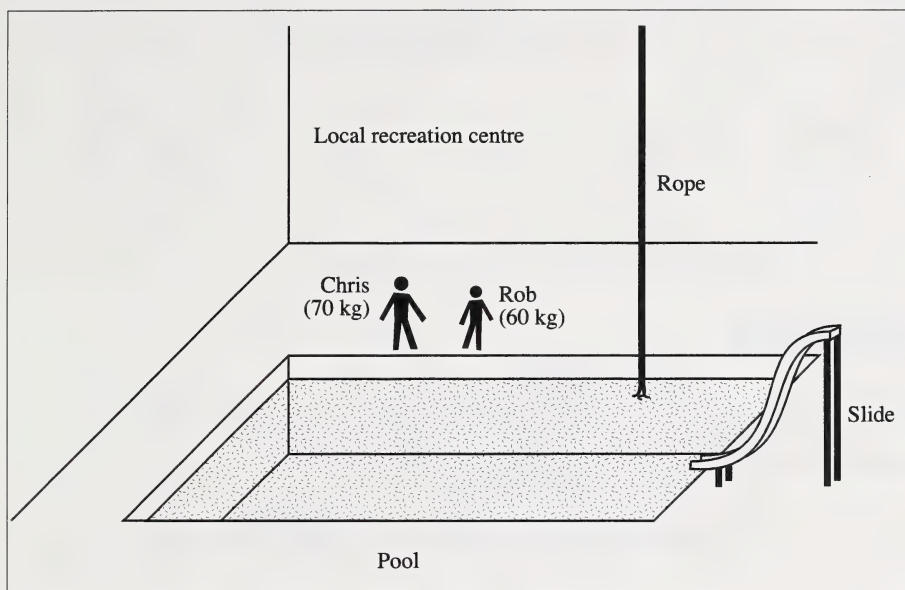
Use the following information to answer the next question.

Part of the training of astronauts involves simulating liftoff acceleration, in which the astronaut sits in a mock capsule that rotates in a horizontal plane around a fixed centre. Assume that the astronaut's centre of mass is 3.60 m from the centre of rotation.



18. If the capsule was spinning at 12.5 m/s, what horizontal force would the circular motion exert on a 70.0 kg astronaut?
- A. 777 kN
B. 3.04 kN
C. 2.35 kN
D. 0.243 kN

Use the following information to answer the next two questions.



19. The boys are trying to decide how long it will take Rob to make one complete swing on the rope, coming back to the pool deck rather than letting himself drop into the water. The rope is about 8 m long. The time Rob's complete swing takes is closest to
- A. 0.2 s
 - B. 5 s
 - C. 6 s
 - D. 17 s

Numerical Response

6. When the waves are turned on in the pool, the boys notice that a wave occurs every 3.0 seconds. Chris says that the frequency would be $a.b \times 10^{-c}$ Hz. The values of a , b , and c are _____. (Record your answer as

a	b	c	
-----	-----	-----	--

.)

20. A 440 g mass is attached to a spring on a horizontal, frictionless surface. The mass is then pulled back 1.6 cm, where the force required to hold it is 4.4 N. If the mass is pulled back further to a displacement of 2.4 cm, then released, the instantaneous acceleration of the mass will be
- A. 2.9 m/s^2
 - B. 4.8 m/s^2
 - C. 15 m/s^2
 - D. 25 m/s^2

Numerical Response

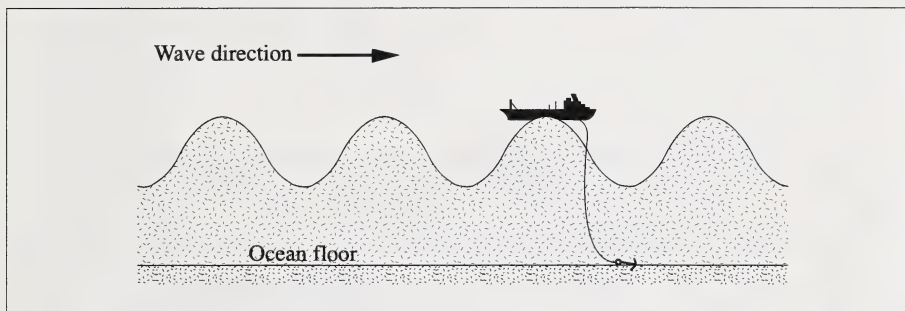
7. Piano tuners often start with middle C. This frequency is 262 Hz. If the speed of sound is 330 m/s, the wavelength produced is _____ m.
(Round and record your answer to three digits.)

Use the information provided in Numerical Response 7 to solve Selected Response 21.

21. The piano tuner checks his work on middle C by using a fork pitched at 264 Hz. What will he hear?
- A. Uniform sound at 264 Hz and 261 Hz
 - B. Uniform sound at 525 Hz
 - C. Beats at 2 Hz
 - D. Beats at 525 Hz

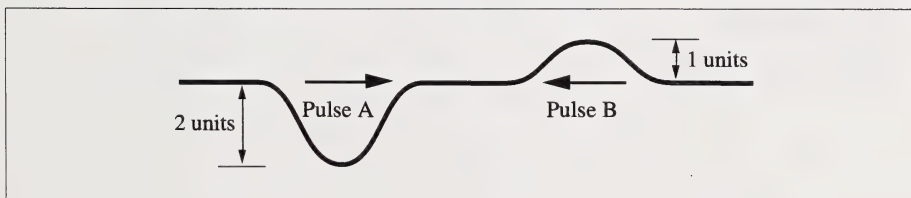
22. When waves on a rope pass from a heavy rope to a light rope, which of the following characteristics does **not** change for the transmitted part of the wave?
- A. Speed
 - B. Frequency
 - C. Wavelength
 - D. Amplitude

Use the following information to answer the next question.



23. An anchored boat moves up and down every 20 s. To increase the gravitational potential energy of the boat with respect to the ocean floor, the
- A. wavelength must increase
 - B. wave period must increase
 - C. wave velocity must increase
 - D. wave amplitude must increase

Use the following diagram to answer the next question.



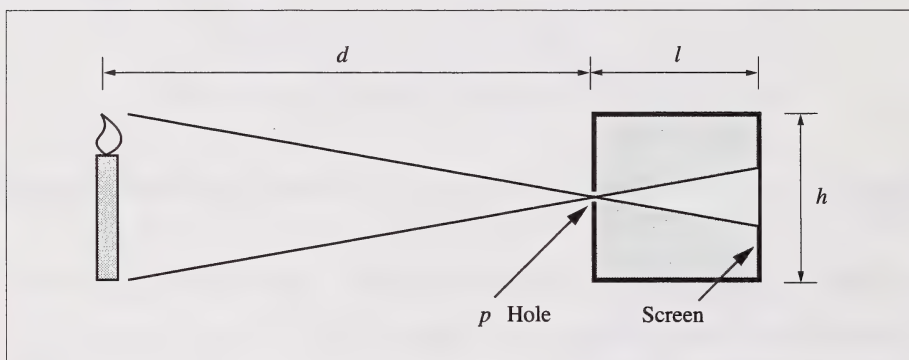
24. When Pulse A and Pulse B of equal length completely overlap, then the resulting amplitude will be
- A. one unit down
 - B. one unit up
 - C. two units down
 - D. two units up

Numerical Response

8. On the planet Garpion, a pendulum with a length of 1.50 m swings with a frequency of 0.575 Hz. The acceleration of gravity on this planet is $ab.c \text{ m/s}^2$. The values of a , b , and c are _____.

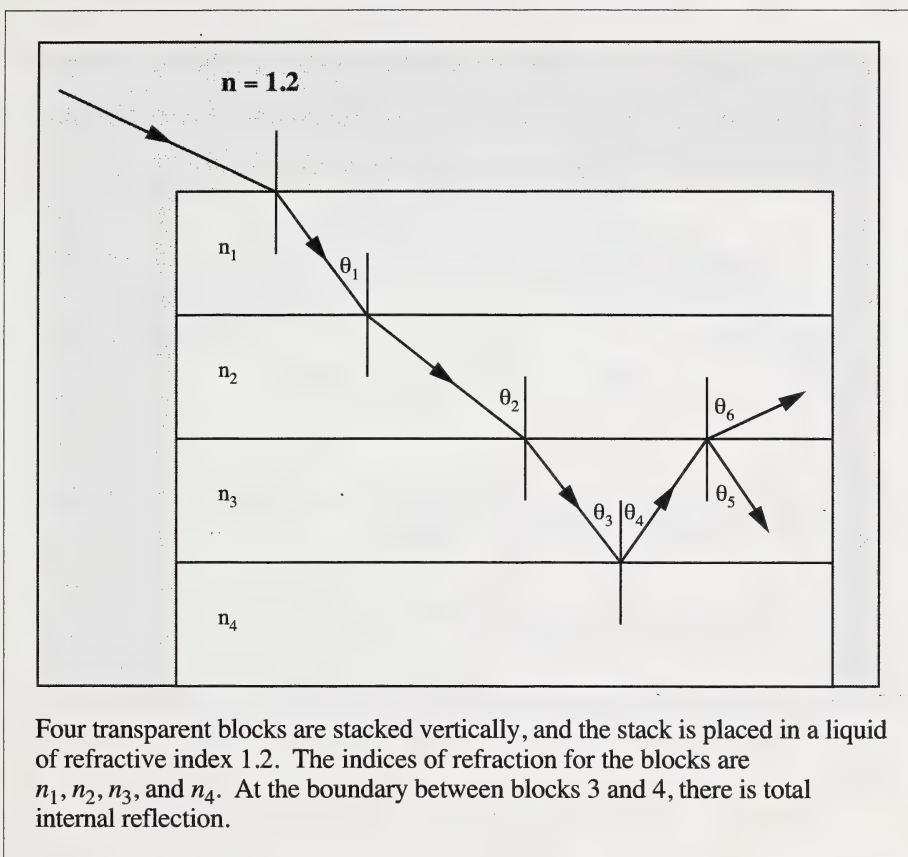
(Record your answer as $\boxed{a}\boxed{b}.\boxed{c}$.)

Use the following diagram to answer the next question.



25. A student who wanted to design a pinhole camera that would increase the size of the image on the screen would have to increase the
- A. distance, d
 - B. size of the hole, p
 - C. length of the camera, l
 - D. height of the camera, h

Use the following information to answer the next question.



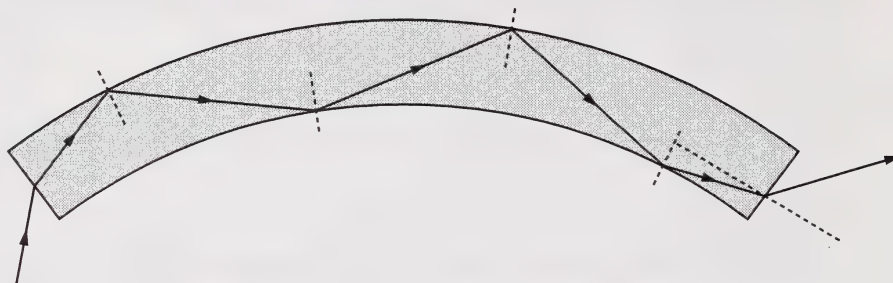
Four transparent blocks are stacked vertically, and the stack is placed in a liquid of refractive index 1.2. The indices of refraction for the blocks are n_1 , n_2 , n_3 , and n_4 . At the boundary between blocks 3 and 4, there is total internal reflection.

26. The angle of reflection θ_5 is equal to

- A. θ_1 and θ_2
- B. θ_2 and θ_3
- C. θ_2 and θ_4
- D. θ_3 and θ_4

Use the following information to answer the next four questions.

Total internal reflection finds important application in the field of fibre optics. An optical fibre is a long, narrow filament of glass or transparent plastic. Because it is narrow, light entering the fibre at one end strikes the inside wall of the fibre at an angle greater than the critical angle.



Since the light is totally reflected inside the fibre, it travels along the fibre, making hundreds of internal reflections without escaping.

27. What is the critical angle between glass ($n = 1.50$) and air ($n = 1.00$)?

- A. 33.7°
- B. 41.8°
- C. 48.2°
- D. 56.3°

Use this additional information to answer the next three questions.

One of your close friends plays on the football team. During last week's game, he received an injury to his right knee. He has been informed that he is to undergo microsurgery that will involve light and fibre-optic technologies. He asks you to give him some background information about the physics involved in his surgery.

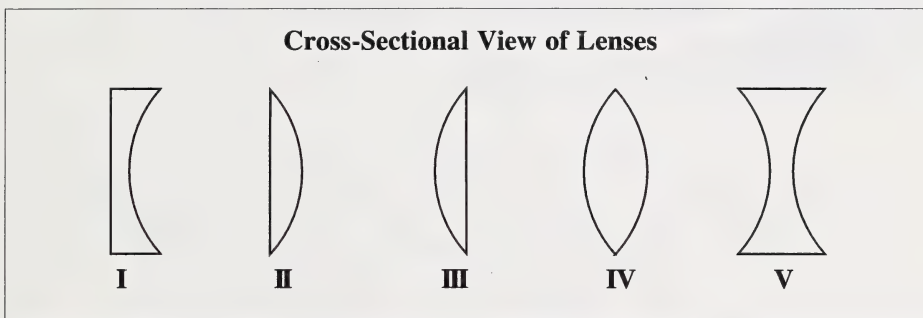
28. Your friend asks you about the speed of light that is used in the fibre-optic procedure he will be going through. You inform him that the speed of the light in the optical fibre will be

- A. 2.00×10^8 m/s
- B. 3.00×10^8 m/s
- C. 4.50×10^8 m/s
- D. 2.40×10^8 m/s

29. Your friend was told that there was “full spectrum imaging.” You explain that full spectrum includes light of 400 nm to 750 nm wavelengths. Your friend asks what the frequency of green light is. You answer

- A. 7.50×10^{14} Hz
- B. 5.45×10^{14} Hz
- C. 4.00×10^{14} Hz
- D. 1.65×10^2 Hz

Use this additional information to answer the next question.



30. As the light leaves the optical fibre, it spreads out and must be focused by a lens to a spot 5 mm in diameter. The lens or lenses that could concentrate the laser light is/are
- A. I, V
 - B. II, III, IV
 - C. IV
 - D. V

Use the following information to answer the next two questions.

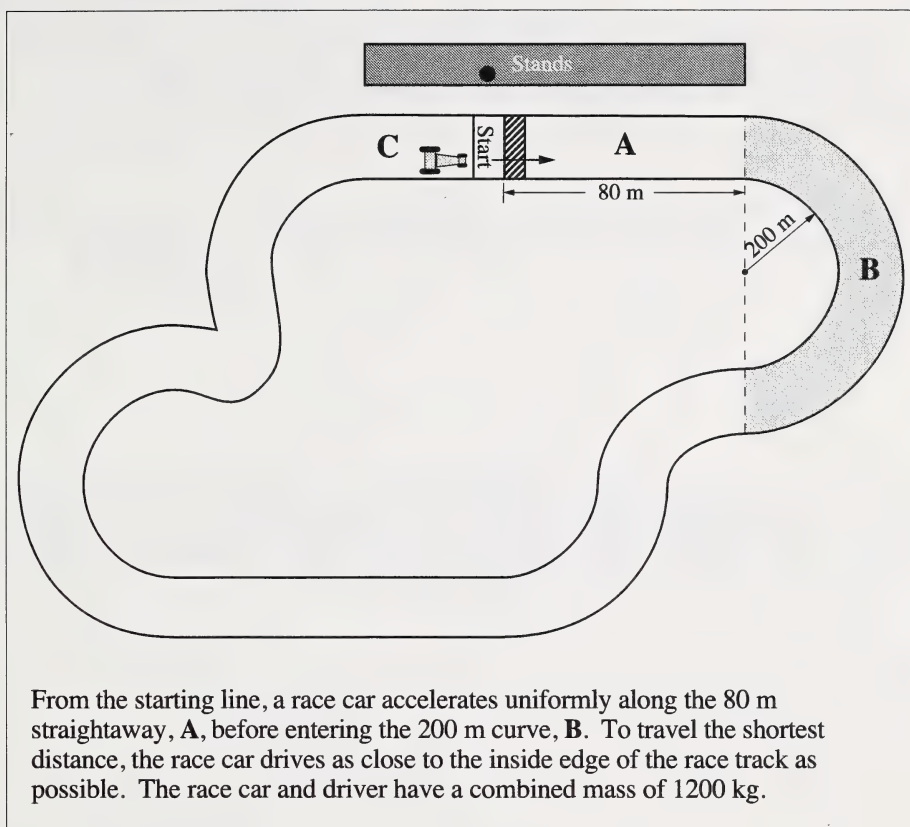
A group of students set up a Young's double-slit experiment, using a sodium vapour lamp as a light source. They placed their diffraction grating 1.0 m from the screen and measured the angle of deviation to be 60° to the first maximum. A resource book listed the frequency of sodium light as 5.09×10^{14} Hz.

Numerical Response

9. The spacing of the openings on the diffraction grating is $b \times 10^{-w}$ m. The value of b is _____.
(Round and record your answer to two digits.)

31. A diffraction grating can be used to measure the wavelength of the light from the sodium vapour lamp, because the light exhibits the phenomena of diffraction and
- A. refraction
 - B. dispersion
 - C. polarization
 - D. interference

Use the following information to answer the next question.



From the starting line, a race car accelerates uniformly along the 80 m straightaway, **A**, before entering the 200 m curve, **B**. To travel the shortest distance, the race car drives as close to the inside edge of the race track as possible. The race car and driver have a combined mass of 1200 kg.

Written Response — 10 marks

1. a. The race car starts from rest and accelerates uniformly at 2.4 m/s^2 along the straightaway. What is its speed when it enters the first turn?

- b. While going around the curve, **B**, the driver wants to go as fast as possible but does not want the car to skid. For the road conditions, the force of friction between the tires and the road is equivalent to 3.2 times the weight of the race car. What is the maximum speed the car can safely have? (**Note:** When $F_c > F_f$, the race car will skid.)
- c. A spectator in the stands near the start line observes that the loudness of the engines increases and then decreases as the race cars travel from **C** to **A**. This is not the only change that is observed as the race cars travel from **C** to **A**. Describe and explain what other change occurs, in terms of sound waves.

Written Response — 11 marks

- 2.** Newton thought light was a stream of particles. Experimental results like those of Foucault, Young, and Poisson have led to the idea that light is a wave. Explain how this evolution occurred. Include experimental results, and explain how these results caused the model to change.

Note: A maximum of 8 marks will be awarded for the physics used to answer this problem.
A maximum of 3 marks will be awarded for the effective communication of your response.

Performance Tasks

- ***Dart Gun***
- ***Geological Surveys***
- ***Building a Flashlight***
- ***Water Waves***

Performance Tasks

Note: The following information applies to each individual performance task.

Description

This is a closed-book performance task. Working individually, you will solve a physics problem set in a real-life context.

Time: 20 minutes. You may take an additional 10 minutes to solve the problem.

Total possible marks: 16

A data sheet is included.

Instructions

Fill in the information required on the front cover as directed by your teacher.

You may use some or all of the supplied materials. You may not use any additional materials. You are expected to provide your own scientific calculator.

Read the problem carefully before you begin your answer. Write your answer in the test booklet as neatly as possible. If you wish to change an answer, erase all traces of your previous answer. Your answers **should be** presented in a neat, well-organized manner using complete sentences, correct units, and significant digits where appropriate. Descriptions and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formula.

Your teacher will have explained the scoring criteria to you. Remember that your work will be scored for Procedure, Observations, Analysis, and Solution to the Problem.

Do not start the task until told to do so by your teacher.

Unit 1: Introduction to the Course

Welcome to the first unit of the course. This unit introduces the course objectives and the structure of the program.

The course is designed to provide a comprehensive overview of the field, covering both theoretical concepts and practical applications. The first unit sets the foundation for the rest of the course.

Course Objectives

By the end of this unit, students should be able to:

1. Understand the scope and goals of the course.

2. Identify the key concepts and theories discussed in the unit.

3. Apply the knowledge gained to solve problems and analyze data.

4. Communicate effectively in written and oral form.

5. Demonstrate critical thinking and problem-solving skills.

6. Collaborate with peers and work in a team.

7. Evaluate the effectiveness of different approaches and methods.

8. Reflect on the learning process and identify areas for improvement.

9. Develop a professional and ethical mindset.

10. Prepare for the challenges of the future.

Practice Task: Dart Gun

Context

Toy manufacturers must always be safety-conscious when designing toys. This is especially true for toys like dart guns. As a physics consultant, your job is to accurately measure the speed at which the dart leaves the gun.

Problem

Determine as accurately as possible the speed at which the dart **leaves** the gun.

Materials

You may use some or all of the following:

- dart gun
- dart
- metre stick
- stopwatch
- masking tape

Instructions

You have 20–30 minutes to design and use a procedure to solve the problem.

- Describe your *procedure*.

Caution: Do not point the dart gun at anyone.

- Communicate your *observations*.
- *Analyze* your results. Include all necessary calculations, graphs, etc., to solve the problem.
- *Solve* the problem and *evaluate* your solution.

Remember that your work will be scored for *procedure*, *observations*, *analysis*, and *solution to the problem*.

Before leaving this station, put all items of equipment back where you found them. **Leave the station as it was when you arrived.**

You may find it helpful to identify the important variables before providing your procedure.

Manipulated (independent) variable _____

Responding (dependent) variable _____

Controlled variable(s) _____

Procedure

Score _____

Observations

Score _____

Trial Number		
1		
2		
3		

Analysis

Score _____

Reread this information as you provide your solution to the problem.

Context

Toy manufacturers must always be safety-conscious when designing toys. This is especially true for toys like dart guns. As a physics consultant, your job is to accurately measure the speed at which the dart leaves the gun.

Problem

Determine as accurately as possible the speed at which the dart **leaves** the gun.

Solution to the Problem

Score _____

Task 1: Geological Surveys

Context

Geo-Co of Alberta is a small company involved in locating natural resources in Alberta. Although it uses ultrasound to pinpoint mineral and oil deposits, the ultrasound machinery is expensive to transport and maintain. As a physics consultant, you tell the board of Geo-Co that you know of a less expensive way to get the general locations of mineral and oil deposits, which they can then pinpoint with the ultrasound equipment. You explain to them that mineral deposits cause an increase in the gravitational field while an oil deposit causes a decrease. The board of Geo-Co approves this method for the generalized locating of natural resources.

Problem

Based on the gravitational field intensity, determine what the ultrasound machinery would show if Geo-Co brought it to where you are right now.

Materials

You may use some or all of the following:

- string
- scissors
- spring
- ruler
- stopwatch
- graph paper
- set of masses
- 100 ml burette
- burette stand
- funnel
- beaker
- water
- tin pie-plate

Instructions

You have 20–30 minutes to design and use a procedure to solve the problem.

- Describe your *procedure*.
- Communicate your *observations*.
- *Analyze* your results. Include all necessary calculations, graphs, etc., to solve the problem.
- *Solve* the problem and *evaluate* your solution.

Remember that your work will be scored for *procedure*, *observations*, *analysis*, and *solution* to the problem.

Before leaving this station, put all items of equipment back where you found them.

Leave the station as it was when you arrived.

You may find it helpful to identify the important variables before providing your procedure.

Manipulated (independent) variable _____

Responding (dependent) variable _____

Controlled variable(s) _____

Procedure

Score _____

Observations

Score _____

Trial Number		
1		
2		
3		

Analysis

Score _____

Reread this information as you provide your solution to the problem.

Context

Geo-Co of Alberta is a small company involved in locating natural resources in Alberta. Although it uses ultrasound to pinpoint mineral and oil deposits, the ultrasound machinery is expensive to transport and maintain. As a physics consultant, you tell the board of Geo-Co that you know of a less expensive way to get the general locations of mineral and oil deposits, which they can then pinpoint with the ultrasound equipment. You explain to them that mineral deposits cause an increase in the gravitational field while an oil deposit causes a decrease. The board of Geo-Co approves this method for the generalized locating of natural resources.

Problem

Based on the gravitational field intensity, determine what the ultrasound machinery would show if Geo-Co brought it to where you are right now.

Solution to the Problem

Score _____

Task 2: Building a Flashlight

Context

You are looking for a part-time job and have applied at Bright Lights, a flashlight manufacturing company. As part of the interview for the job, the president of the company tells you that concave mirrors are used to make flashlights. Then she hands you a concave mirror and asks if it would be a good mirror for a flashlight. Your chances for the job will depend upon your answer.

Problem

Determine quantitatively whether this mirror will make a good flashlight.

Materials

You may use some or all of the following:

- concave mirror
- ruler
- light bulb (small) & energy source, or candle & matches
- cardboard sheet
- 3 pushpins
- metre stick
- plasticene

Instructions

You have 20–30 minutes to design and use a procedure to solve the problem.

- Describe your *procedure*.
- Communicate your *observations*.
- *Analyze* your results. Include all necessary calculations, graphs, etc., to solve the problem.
- *Solve* the problem and *evaluate* your solution.

Remember that your work will be scored for *procedure*, *observations*, *analysis*, and *solution to the problem*.

Before leaving this station, put all items of equipment back where you found them.

Leave the station as it was when you arrived.

You may find it helpful to identify the important variables before providing your procedure.

Manipulated (independent) variable _____

Responding (dependent) variable _____

Controlled variable(s) _____

Procedure

Score _____

Observations

Score _____

Trial Number		
1		
2		
3		

Analysis

Score _____

Reread this information as you provide your solution to the problem.

Context

You are looking for a part-time job and have applied at Bright Lights, a flashlight manufacturing company. As part of the interview for the job, the president of the company tells you that concave mirrors are used to make flashlights. Then she hands you a concave mirror and asks if it would be a good mirror for a flashlight. Your chances for the job will depend upon your answer.

Problem

Determine quantitatively whether this mirror will make a good flashlight.

Solution to the Problem

Score _____

Task 3: Water Waves

Context

You are spending a summer day at a lake. You have left your towel and radio just above the water on the shore while you are swimming. Suddenly, a large powerboat goes by 30 m from the shore and creates a large wave. How much time do you have to rescue your radio and towel before the wave reaches them?

Problem

Determine the time for the wave to reach the shore.

Materials

You may use some or all of the following:

- 1 large bucket or ripple tank
- water
- model boat
- stop watch
- ruler
- marble
- metre stick
- string
- speed conversion graph

Instructions

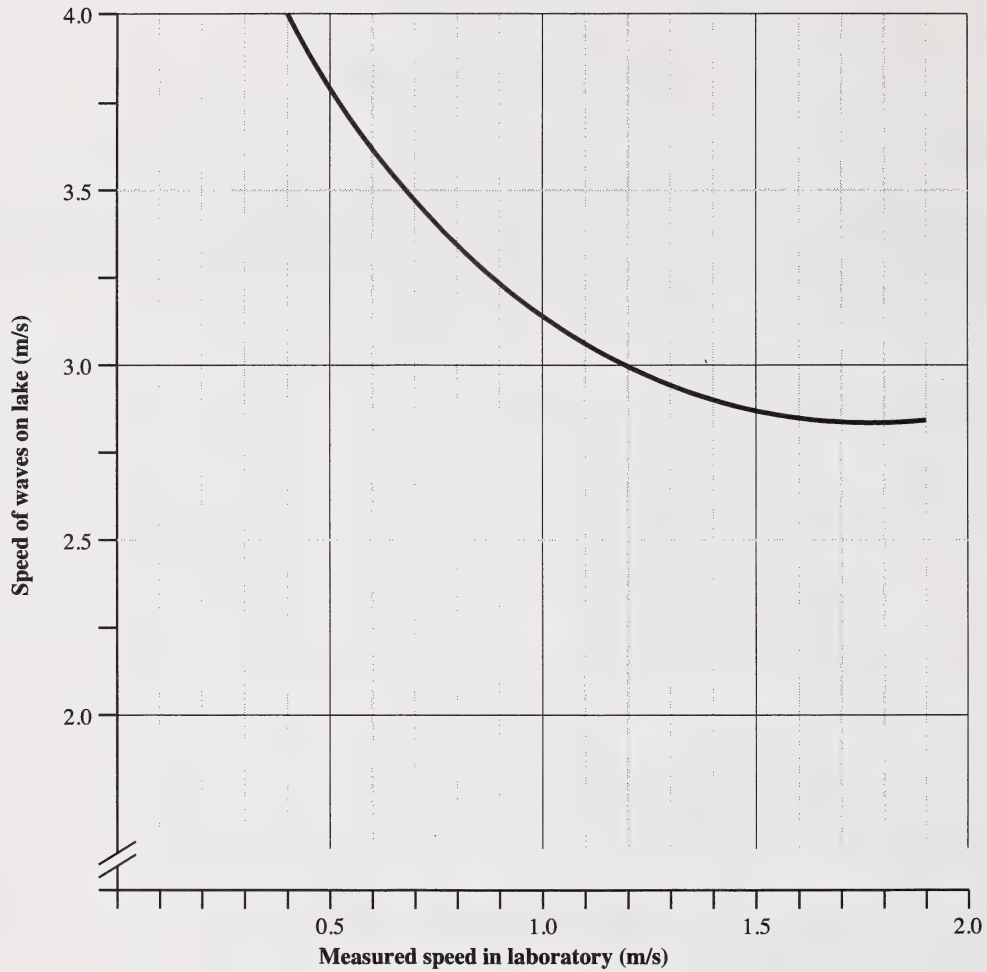
You have 20–30 minutes to design and use a procedure to solve the problem.

- Describe your *procedure*.
- Communicate your *observations*.
- *Analyze* your results. Include all necessary calculations, graphs, etc., to solve the problem.
- *Solve* the problem and *evaluate* your solution.

Remember that your work will be scored for *procedure*, *observations*, *analysis*, and *solution to the problem*.

Before leaving this station, put all items of equipment back where you found them. **Leave the station as it was when you arrived.**

Speed Conversion Graph



You may find it helpful to identify the important variables before providing your procedure.

Manipulated (independent) variable _____

Responding (dependent) variable _____

Controlled variable(s) _____

Procedure

Score _____

Observations

Score _____

Analysis

Score _____

Recall this information as you provide your solution to the problem.

Context

You are spending a summer day at a lake. You have left your towel and radio just above the water on the shore while you are swimming. Suddenly, a large powerboat goes by 30 m from the shore and creates a large wave. How much time do you have to rescue your radio and towel before the wave reaches them?

Problem

Determine the time for the wave to reach the shore.

Solution to the Problem

Score _____

CONSTANTS

Gravity, Electricity, and Magnetism

Acceleration Due to Gravity or Gravitational Field Near Earth..... 9.81 N/kg or 9.81 m/s^2 or a_g or $g = 9.81 \text{ m/s}^2$ or 9.81 N/kg

Gravitational Constant..... $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

Mass of Earth..... $M_e = 5.98 \times 10^{24} \text{ kg}$

Radius of Earth..... $R_e = 6.37 \times 10^6 \text{ m}$

Orbital Radius of Earth..... $R = 1.4957 \times 10^{11} \text{ m}$

Index of Refraction of Air..... $n = 1.00$

Index of Refraction of Water..... $n_w = 1.33$

Speed of Light in Vacuum..... $c = 3.00 \times 10^8 \text{ m/s}$

Speed of Sound at 0°C $v_0 = 332 \text{ m/s}$

Speed of Sound at 20°C $v_{20} = 343 \text{ m/s}$

Trigonometry and Vectors

For any Vector $\vec{R}$

$$\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan \theta = \frac{\text{opposite}}{\text{adjacent}}$$

$$R = \sqrt{R_x^2 + R_y^2}$$

$$\tan \theta = \frac{R_y}{R_x}$$

$$R_x = R \cos \theta$$

$$R_y = R \sin \theta$$

EQUATIONS

Kinematics

$$\bar{v}_{\text{ave}} = \frac{\bar{d}}{t}$$

$$\bar{a} = \frac{\bar{v}_f - \bar{v}_i}{t}$$

$$\bar{d} = \bar{v}_i t + \frac{1}{2} \bar{a} t^2$$

$$\bar{d} = \bar{v}_f t - \frac{1}{2} \bar{a} t^2$$

$$\bar{d} = \left(\frac{\bar{v}_i + \bar{v}_f}{2} \right) t$$

$$v_f^2 = v_i^2 + 2ad$$

Dynamics

$$\vec{F} = m\vec{a}$$

$$\vec{F}\Delta t = m\Delta\vec{v}$$

$$\vec{F}_g = m\vec{g}$$

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$g = \frac{Gm_1}{r^2}$$

$$F_c = \frac{mv^2}{r}$$

$$F_c = \frac{4\pi^2mr}{T^2}$$

$$\vec{F}_s = k\vec{x}$$

Energy and Power

$$W = Fd$$

$$W = \Delta E = Fd \cos \theta$$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$

$$E_k = \frac{1}{2}mv^2$$

$$E_p = mgh$$

$$E_p = \frac{1}{2}kx^2$$

Waves and Light

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T = \frac{1}{f}$$

$$v = f\lambda$$

$$\frac{\lambda_1}{2} = l; \frac{\lambda_1}{4} = l$$

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

$$\lambda = \frac{xd}{nl}$$

$$\lambda = \frac{d \sin \theta}{n}$$

$$m = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

Written Response 2—Scoring Criteria for Communication

Standard	Criteria
3	<i>The student response</i> - is complete and well organized, and the explanation of the solution is relevant, appropriate, and clear - describes the strategy in detail and in a logical manner, demonstrating consistency of thought - uses physics vocabulary appropriately, and a precise, explicit relationship exists between the explanation and diagrams - explicitly states the formula, if used - may contain a mathematical error, but this does not hinder the understanding of either the strategy or the solution
2	- is organized, and the attempt to explain the solution is appropriate; however, errors sometimes affect the clarity of the explanation - describes the strategy, but details are generally and/or sometimes lacking, leaving it somewhat open to interpretation - sometimes misuses physics vocabulary; an implicit relationship exists between explanation and diagrams (if used) - may not state the formula, which may, however, be inferred by analyzing the calculations - may contain mathematical errors that can hinder the understanding of either the strategy or the solution
1	- lacks organization, and the attempt to explain all aspects of the problem is not evident; errors affect the clarity of the explanation - describes a strategy that provides little or no detail - often misuses physics vocabulary; a weak relationship exists between the explanation and diagrams (if used) - calculations may appear, but the relationship between the calculations and the solution is unclear - may contain mathematical errors that hinder the understanding of the strategy and/or the solution
0	- is not organized, and there is little or no attempt to explain any aspect of the problem - does not describe a strategy to solve the problem - uses little or no physics vocabulary, and misuses what there is; no relationship exists between the explanation and diagram (if present) - may state a formula that does not contribute toward the solution - is confusing and/or frustrating to the reader - contains very little information
NR	No response is given

Written Response 2—Scoring Criteria for Foundations of Scientific Knowledge

Standard	Criteria
4	<i>The student response</i> - is well organized and addresses all major points of the question - explicitly identifies and interrelates relevant scientific, technological, and/or societal concepts - contains descriptions and/or explanations that reflect a thorough understanding and logical consistency of thought - uses correct diagrams and/or sketches to illustrate descriptions and/or explanations - may contain omissions or inconsistencies, but the understanding of the solution is clear
3	- is organized and addresses most of the major points of the question - identifies and interrelates relevant scientific, technological, and/or societal concepts - contains descriptions and/or explanations that are organized and that reflect a good understanding and logical consistency of thought - uses correct diagrams and/or sketches to illustrate descriptions and/or explanations - contains at most one major omission or inconsistency
2	- has some organization and addresses some of the major points of the question - implies relevant scientific, technological, and/or societal concepts; interrelationships are weak - shows some understanding in the descriptions and/or explanations
1	- addresses some of the major points of the question - shows little understanding - identifies concepts, but shows no interrelationships - superficially describes and/or explains the concepts - shows minimal organizational skills
0	does not address any of the major points of the question
NR	No response is given

Marking:

The marks are arrived at in the following manner:

Take the level of the response from the
Scoring Criteria for Foundations of Scientific Knowledge

and multiply by two; e.g.,

$$4 \times 2 = 8$$

Add the score from the

Scoring Criteria for Communication; e.g.,

$$8 + 3 =$$

11

Holistic Scoring Criteria for Procedure

When marking the **PROCEDURE**, consider how effectively the response uses **physics concepts, knowledge, and skills** to show how the procedure would give data to solve the problem.

Level	Criteria
4	The problem is thoroughly understood . An appropriate and practical procedure is presented in a clear sequence . The data to be collected would be accurate and would solve the problem. Any omissions or inconsistencies do not hinder the communication of the procedure.
3	The problem is well understood . An appropriate and practical procedure is presented, but the data to be collected would be insufficient to solve the problem. Any omissions or errors in the sequence affect the validity of the data to be collected.
2	The problem is understood . A practical procedure, with major omissions or errors, that could be followed only by someone who knew what was being looked for is presented. The data to be collected may be too inaccurate to solve the problem.
1	The problem is poorly understood . The procedure is incomplete and the method used to obtain the data is inappropriate . Sufficient description is provided that the marker can infer that the data, if collected, could have been used to solve the problem.
0	The problem is not understood . The procedure, if evident, would generate data that would not be useful in solving the problem.

Holistic Scoring Criteria for Observations

When marking **OBSERVATIONS**, consider how effectively the response **communicates** the outcomes of the procedure.

Level	Criteria
4	The data gathered are consistent with the procedure. The observations and results are complete . They are clearly and logically recorded . The observations communicate multiple trials, where appropriate, to solve the problem. Correct scientific conventions of communication are evident in precision of measurements and units .
3	The data gathered are mostly consistent with the procedure. The observations and results are mostly complete : they may contain omissions or errors, but the problem is still solvable. Scientific conventions of communication are used.
2	The data gathered relate to the procedure. The observations and results are incomplete , and it is likely that the problem cannot be solved with these results. The use of scientific conventions of communication is inconsistently followed.
1	The data gathered relate to the procedure. Scientific conventions of communication are absent.
0	The data gathered are unrelated to the procedure or no observations are made.

Holistic Scoring Criteria for Analysis

When marking **ANALYSIS**, consider how effectively the response uses **physics concepts, knowledge, and skills** to use the observations and results to solve the problem.

Level	Criteria
4	The analysis is well organized and thoroughly understood . The mathematical treatment of the observations and results is correct , including formulas, calculations, graphs, significant digits, and units, etc. The data are accurately and completely analyzed. Minor errors may exist in the analysis.
3	The analysis is mostly organized and mostly understood . The mathematical treatment of the observations and results is generally correct . The data are analyzed, but some errors or inaccuracies exist.
2	The analysis has some level of organization and shows some understanding . The mathematical treatment of the observations and results is only partially correct . The calculations may be inaccurate for the observations obtained.
1	The analysis is disorganized . The mathematical treatment is incomplete and inaccurate .
0	No analysis is done.

Holistic Scoring Criteria for the Solution to the Problem

When marking the **SOLUTION TO THE PROBLEM**, consider how effectively the response **communicates** the solution.

Level	Criteria
4	A solution to the problem is given, using appropriate scientific conventions of significant digits and units where appropriate. The solution is thoroughly supported by the analysis. The evaluation of the solution is properly made in terms of the believability of the solution and any errors in the procedure.
3	A solution to the problem is given that is generally supported by the analysis. The evaluation of the solution is poorly made.
2	A solution to the problem is given that is generally supported by the analysis. Evaluation of the solution is ignored .
1	A solution to the problem is given, but is not supported by the analysis. Evaluation of the solution is missing .
0	No solution is given. No evaluation is made.



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